ECE 3600   homework # 15

1. A $60\,Hz$, 2-pole, 3-phase synchronous generator supplies power to a $12.5\,kV$ bus. The synchronous reactance is 4 Ω/phase. The generator emf is $7\,kV\,\underline{/20°}$ (the angle is referenced to the terminal voltage). Find the following.

   a) The total power generated.

   b) The total reactive power generated.

   c) The shaft torque from the prime mover, neglecting friction.

   d) Increase the magnitude of the generator emf so that $Q := 0 \cdot VAR$ The prime mover torque does not change.
      Note: If the prime mover torque doesn't change, neither does P. δ can change.

   e) The new power angle, δ.

   f) Increase the magnitude of the generator emf so that $Q := 9 \cdot MVAR$

   g) The new power angle, δ.

2. 4.39 Refer to the per-phase phasor diagram at right.
   It is for a 12-pole, three-phase synchronous machine.

   a) Is the machine operating as a motor or a generator?

   b) What is the voltage and apparent power into/out of the machine?

   c) Determine the synchronous reactance of the machine.

   d) For the same real power, what magnitude of excitation voltage
      yields unity power factor?

$$\mathbf{I} = 20\angle{+20°}$$
$$\mathbf{V} = (230\sqrt{3})\angle{0°}$$
$$\underline{\mathbf{E}}_f = 151.2\angle{-14.4°}$$
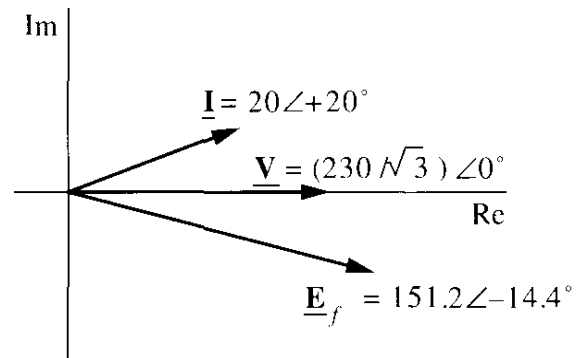
3. 4.41. A cylindrical-rotor, 60-Hz, three-phase, 12-pole synchronous motor operates from 2300 V and produces 500 hp. The motor operates with unity power factor with an excitation voltage of E = 1620 V per phase. Neglect losses. Determine the following:

   a) The current.

   b) The synchronous reactance.

   c) The torque.

   d) The rotor power angle.

4. 4.43. The per-phase phasor diagram for a three-phase, 60-Hz,
   8-pole synchronous motor is shown. Note that all sides and two
   angles of the triangle are shown. The current/phase is 21 A

   a) Is the motor overexcited or underexcited?

   b) What is the rotor power angle?

   c) What is the power factor and is it leading or lagging?

   d) Determine the synchronous reactance per phase.

   e) Determine the output power and torque, neglecting mechanical losses.

$$\underline{\mathbf{V}} = \frac{240}{\sqrt{3}}\angle{0°}$$
$$110.1°$$
$$\text{Length} = 122.4\,V$$
$$\underline{\mathbf{E}}_f = 151.2\angle{-50°}$$
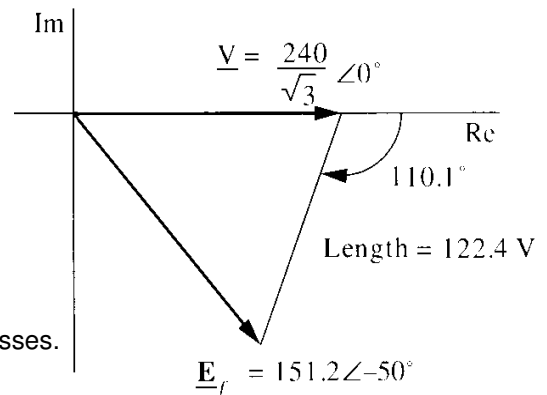
Answers

1. a) $12.96 \cdot MW$ b) $-3.459 \cdot MVAR$ c) $3.437 \cdot 10^4 \cdot N \cdot m$ d) $7.604 \cdot kV$ e) $18.35 \cdot deg$ f) $9.20 \cdot kV$ g) $15.1 \cdot deg$

2. a) motor   b) $132.8 \cdot V$ $2.656 \cdot kVA$ c) $2 \cdot \Omega$ d) $E_{af} = 138 \cdot V$

3. a) $93 \cdot 6 \cdot A$ b) $9.92 \cdot \Omega$ c) $5934 \cdot N \cdot m$ d) $34.95 \cdot deg$

4. a) underexcited   b) $-50 \cdot deg$ c) 0.939 lagging   d) $5.83 \cdot \Omega$ e) $11 \cdot hp$ $87 \cdot N \cdot m$

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